Design and Installation of a Pilot Plant for High-Volume Electrode Production

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Subcontractors:
General Motors, Warren, MI
W.L. Gore & Associates, Inc., Elkton, MD

Objectives

- Significantly reduce overall membrane electrode assembly (MEA) cost by developing vacuum catalyzation methods that can meet DOE precious metal loading targets of 0.2 g/rated kW by 2010.
- Improve prospects for practical implementation of fuel cell technology in high-volume applications by demonstrating scalable, high-throughput manufacturing technologies.
- Evaluate performance of materials under relevant fuel cell operating conditions to confirm process viability.
- Complete process development and qualification of a pilot manufacturing plant.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year R,D&D Plan:

- O. Stack Material and Manufacturing Cost

Approach

- Determine the impact of large-scale catalyzation methods on MEA performance, if any, and develop approaches to minimize them.
- Establish in situ process control methods for catalyst deposition and demonstrate high-efficiency metal recovery approaches.
- Benchmark MEAs fabricated at SwRI against commercially available products.
- Incorporate SwRI-manufactured MEAs into two "short stack" fuel cells built by General Motors (GM) and deliver to Argonne National Laboratory for testing and evaluation.

Accomplishments

- Continued work with pilot manufacturing system, catalyzing over 3000 linear feet of electrode material as part of ongoing process optimization and production yield studies.
- Completed assembly and initial testing of hydrogen-air and reformate-air fuel cell stacks at GM.
- Conducted single-cell durability testing over 500+ hours in conjunction with Gore.

Future Directions

- Deliver stacks to Argonne National Laboratory for further testing and evaluation.
- Continue process development and optimization in anticipation of transitioning technology to full-scale production.
- Adapt vacuum deposition methods to fabrication of ultra-thin Pd alloy membranes for hydrogen purification (new DOE project).
- Examine feasibility of vacuum deposition methods in development of reversible fuel cells and non-precious metal catalysts.

Introduction

Progress in the adoption of fuel cell technology in the automotive area will depend to a large extent on the economics of catalyst utilization, the MEA production system, and the resultant performance in a fuel cell system. Recent cost analyses have suggested that MEAs can constitute as much as 80% of the cost of a fuel cell stack. Hence, improvements in the inherent performance of MEAs while substantially reducing the catalyst content per unit area will contribute significantly to lowering the cost of producing fuel cell generated power. The development of manufacturing concepts permitting the continuous and high-speed catalyzation of electrodes should have a significant beneficial impact on the cost of the MEAs and the dollars per kilowatt of power produced by the fuel cell.

Until recently, most MEAs were produced in time-consuming, batch-type processes. This situation has existed because of generally low volume purchases of MEAs and the large variety of MEA sizes and configurations required by the various fuel cell systems manufacturers. In effect, the industry is in a "chicken and egg" situation where low-price components, including MEAs, are required for high-volume commercialization of fuel cells, yet component suppliers need high volumes to attain low prices. Without a large present market, the investment risk is considerable and may be beyond the means of any industrial entity.

High-volume, continuous operations capable of producing sub-components such as electrodes should dramatically reduce the cost of the finished product. Southwest Research Institute (SwRI) is investigating this proposition by developing large-area, vacuum-based electrode substrate coating technologies to reduce overall material content of the finished part. Specifically, "ultra-low" precious metal loaded electrodes with loadings of 0.10 mg/cm^2 or less have been fabricated using state-of-the art polymer electrolyte membranes and electrode substrates procured from Gore. The best-performing MEAs have been delivered to General Motors for the construction and supply of two fuel cell "short stacks" to Argonne National Laboratory (ANL).

Approach and Results

Activities in the past year have focused on further investigations of optimal materials processing conditions using the vacuum roll coater. Several thousand linear feet of additional intermediate electrode material has been supplied by Gore over the past year for use with this system. Pilot quantities of catalyzed electrode material (Figure 1), up to 500 linear feet per run, have been prepared and

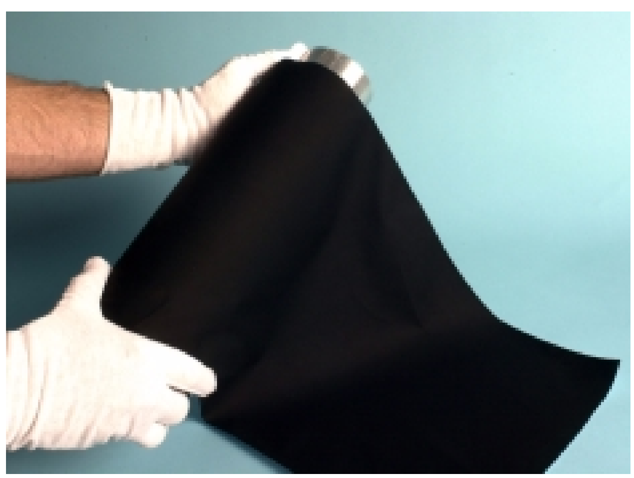

Figure 1. Vacuum-Catalyzed Intermediate Electrode Material

evaluated using standardized test methods. These materials have in turn been used to fabricate full-scale MEAs utilizing state-of-the-art GORE-SELECT® membranes (Figure 2).

A small number of fuel cell "short stacks", each typically 803 cm^2 active area and consisting of 14 cells using composite plates, have been assembled and tested at GM. Each stack contains both baseline and experimental MEAs that can be individually monitored for "side-by-side" testing and comparison. The hydrogen-air stack utilizes a total precious metal loading of 0.2 mg/cm^2 and has generated a peak power of approximately 5 kW operating at 220 kpa pressure with hydrogen and air stoicheometries of 1.2 and 2.0, respectively. In laboratory tests, smaller single cells (25-100 cm^2) were fabricated with total loadings of ~0.1 mg/cm^2 and have generated power densities of more than 1.0 A/cm^2 at 0.6 V running at similar pressures and stoicheometries. In an effort to more fully characterize the performance of ultra-low load electrodes, the effects of cathode humidification, gas diffusion media, cell compression, and cell assembly have been investigated. In support of this effort, W.L. Gore and Associates has also been conducting performance and durability life testing of samples fabricated at SwRI. The results to date have suggested that, while durability goals may be even more challenging with low loading electrodes compared to high loading samples independent of the catalyst deposition method used, this particular technology has significant value in enabling low-loading MEAs to meet the required power density targets.

Figure 2. Full-Scale MEA for GM Test Stack

Conclusions

A pilot manufacturing facility has now been completed that has the capability to catalyze more than 100,000 square meters of electrode material on a three-shift basis - enough to facilitate the production of MEAs for tens of thousands of fuel cell-powered automobiles. Pilot quantities of catalyzed electrode material, up to 500 linear feet per run, have been prepared, with small scale (25-100 cm^2 active area) and full scale (up to 800 cm^2 active area) MEAs fabricated using the prepared electrode materials. Selected examples have been provided to W.L. Gore and GM for testing, evaluation, and, incorporation into two fuel cell stacks. The first hydrogen-air stack has generated a peak power of approximately 5 kW and is being prepared for delivery to ANL. The second stack, configured to run on reformate, is scheduled for final test and shipment before the end of the fiscal year.